Particulate Matter, Nitrogen Oxides, and Carbon Monoxide Source Test Report

Bitter Root RC&D Area, Inc. Darby Public Schools Fuels for Schools Project

Test Date: April 12 and 13, 2004
Aspen File: BRT04042

Prepared for:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY

Aspen Consulting & Engineering, Inc. (Aspen) was retained by Bitter Root RC&D Area, Inc. (Bitter Root RC&D) to conduct emissions testing at the Darby Public Schools wood-fired boiler located in Darby, Montana. Aspen performed emissions testing consisting of particulate matter (PM), nitrogen oxides (NO_x), and carbon monoxide (CO) tests on the Darby Schools wood fired boiler emissions stack.

The purpose of the source testing was to determine PM, NO_x, and CO emission rates as well as the stack flow rate and dilutant oxygen (O_2), and carbon dioxide (CO_2) concentrations. Testing was conducted for information purposes only.

Table ES-1 below is a summary of the PM, NO_x, and CO emissions test results for the wood-fired boiler tested under this test campaign.

TABLE ES-1
SUMMARY OF PM, NO_X, AND CO EMISSION RESULTS
WOOD-FIRED BOILER
DARBY PUBLIC SCHOOLS
DARBY, MONTANA

Source	Average of 3 Test Runs
PM (gr/dscf)	0.061
PM (lb/hr)	0.468
NO_x (lb/hr)	0.365
CO (lb/hr)	0.499

Notes:
PM Particulate Matter
NO_x Nitrogen Oxides
CO Carbon Monoxide
gr/dscf Grains per Dry Standard Cubic Foot
lb/hr Pounds per Hour

1.0 INTRODUCTION

Aspen Consulting & Engineering, Inc. (Aspen) was retained by Bitter Root RC&D Area, Inc. (Bitter Root RC&D) to conduct emissions testing at the Darby Public Schools wood-fired boiler located in Darby, Montana. Aspen performed emissions testing consisting of particulate matter (PM), nitrogen oxides (NO_x), and carbon monoxide (CO) tests on the Darby Public Schools wood-fired boiler emissions stack.

The purpose of the source testing was to determine PM, NO_x, and CO emission rates as well as the stack flow rate and dilutant oxygen (O_2), and carbon dioxide (CO_2) concentrations. Testing was conducted for Bitter Root RC&D's information purposes only.

Results of the emissions tests at the Darby Public Schools wood-fired boiler are presented in Section 3.0.

2.0 FACILITY AND EMISSION SOURCE OPERATION

The Darby Public Schools facility consists of three main buildings that are heated by the wood-fired boiler tested under this campaign. The three buildings consist of classrooms and gymnasiums for kindergarten through twelfth grade. The schools also have three oil-fired boilers that are used for backup of the wood-fired boiler.

The wood-fired boiler is a Hurst boiler rated at 3 million British thermal units (MMBtu) per hour. The boiler is housed in a separate building on the school grounds and was designed by Messersmith Manufacturing.

3.0 SUMMARY OF RESULTS

The following is a summary of the production data and emissions results obtained during the April 12 and 13, 2004 test campaign conducted by Aspen.

3.1 PRODUCTION RATES

No formal production data was obtained from the Hurst boiler; however, certain parameters were recorded during the testing. The Hurst boiler ran at 75 percent capacity during all three test runs. The boiler ran at "high fire" for the first and second runs (Run 1 on April 12, 2004 and Run 2 on April 13, 2004). The boiler ran at high fire for the first ten minutes of Run 3 (April 13, 2004) and at "medium fire" for the following 50 minutes of the test run (test runs are 60 minutes in duration).

3.2 PARTICULATE MATTER

Three 60-minute PM emission test runs were conducted at the Hurst boiler stack. PM results include filter and probe rinse weights. Table 3-1 presents the PM test data obtained from the Hurst boiler stack test during the April 12 and 13, 2004 emissions testing. Analytical data are provided in Appendix A.

TABLE 3-1
SUMMARY OF PARTICULATE MATTER RESULTS
WOOD-FIRED BOILER

DARBY PUBLIC SCHOOLS
DARBY, MONTANA

Parameters	Run 1	Run 2	Run 3	Average	Limit
Moisture (%)	10.7	11.3	11.0	11.0	NA
Isokinetis (%)	110	109	109	NA	100±10
Flow Rate (dscfm)	964	920	787	892	NA
PM (gr/dscf)	0.068	0.059	0.056	0.061	NA
PM (lb/hr)	0.561	0.465	0.378	0.468	NA

Notes:
PM Particulate Matter (Front-Half)
dscfm Dry Standard Cubic Feet per Minute
gr/dscf Grains per Dry Standard Cubic Foot
lb/hr Pounds per Hour
NA Not Applicable

PM field data sheets, spreadsheets, and sample calculations are presented in Appendix B.

3.3 NITROGEN OXIDES, CARBON MONOXIDE, AND DILUTANT GASES

Three 60-minute NO_x, CO, O_2, and CO_2 emission test runs were conducted at the Hurst boiler stack simultaneously with the PM tests. Table 3-2 presents the gaseous test data obtained from the Hurst boiler stack test during the April 12 and 13, 2004 emissions testing.

TABLE 3-2
SUMMARY OF GASEOUS EMISSION RESULTS
WOOD-FIRED BOILER
DARBY PUBLIC SCHOOLS
DARBY, MONTANA

Parameters	Run 1	Run 2	Run 3	Average
NO_x (ppm)	58.37	56.96	56.20	57.18
NO_x (lb/hr)	0.403	0.376	0.317	0.365
CO (ppm)	134.65	131.45	117.07	127.73
CO (lb/hr)	0.566	0.528	0.402	0.499
O_2 (%)	11.4	11.3	11.6	11.4
CO_2 (%)	8.9	9.0	8.6	8.8

Notes:

NOx	Nitrogen Oxides
CO	Carbon Monoxide
O2	Oxygen
CO2	Carbon Dioxide
ppm	Parts per Million
lb/hr	Pounds per Hour

Field data sheets and spreadsheets for gaseous emissions testing are provided in Appendix B.

4.0 METHODS AND CALCULATIONS

All emissions testing was performed in accordance with Environmental Protection Agency (EPA) methods as described in Title 40 of the Code of Federal Regulation (CFR) Part 60, Appendix A. The specific methods employed during the tests are listed below.

METHOD 1 – "Sample and Velocity Traverses For Stationary Sources"

Appropriate sampling point locations were determined using Method 1 procedures. Stack dimensions, number of ports, and number of traverse points for testing were determined the day of the test. Figure 4-1 shows the stack dimensions measured on the day of testing. Based on stack dimensional measurements, 20 sampling points were utilized (10 points per port) for accurate PM testing. Table 4-1 provides the traverse point locations for each port on the Hurst boiler stack.

FIGURE 4-1
STACK DIMENTIONS

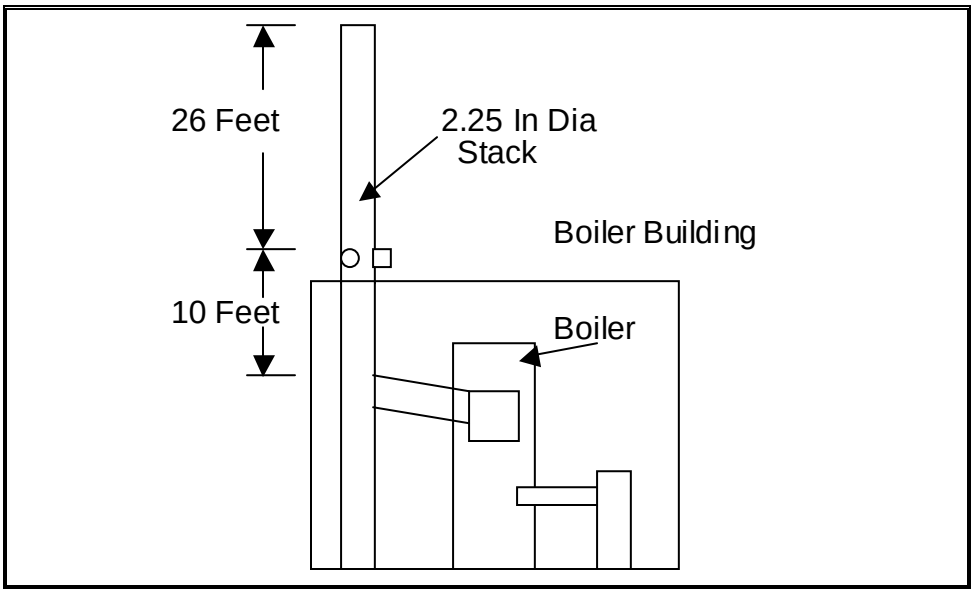


TABLE 4-1
TRAVERSE POINT LOCATIONS

Point Number	Distance From Stack Wall (inches)	Port Length (inches)	Total Distance (inches)
1	0.6	10	10.6
2	1.7	10	11.7
3	3.1	10	13.1
4	4.7	10	14.7
5	7.2	10	17.2
6	13.8	10	23.8
7	16.3	10	26.3
8	17.9	10	27.9
9	19.3	10	29.3
10	20.5	10	30.5

METHOD 2 – "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"

Method 2 was included in the Method 5 tests.

METHOD 3A – "Gas Analysis for the Determination of Dry Molecular Weight (Instrumental Analyzer Method)"

Three Method 3A tests were performed simultaneously with the PM emission tests at the Hurst boiler. The molecular weight was determined by measuring the oxygen (O_2) and carbon dioxide (CO_2) percentages in the boiler exhaust. The method assumes that nitrogen (N_2) is also present in the exhaust stream and the difference of the O_2 and CO_2 subtracted from 100 is equal to the percentage of nitrogen. The dry molecular weight (M_d) is calculated by the following formula.

$$M_d = (0.440)(\%CO_2) + (0.320)(\%\ O_2) + (0.280)(\%N_2 + \%CO)$$

Percentages of CO measured in the inlet and outlet stack were too low to use in this equation.

A Servomex model 1400 analyzer measured the O_2 and CO_2 concentrations. This analyzer measures O_2 using paramagnetic technology, and measures CO_2 using infrared technology. The sampling system consisted of a probe, heated filter, heated sample line, condenser, pump, and sample manifold. Figure 4-3 shows a schematic of the O_2 and CO_2 sampling system

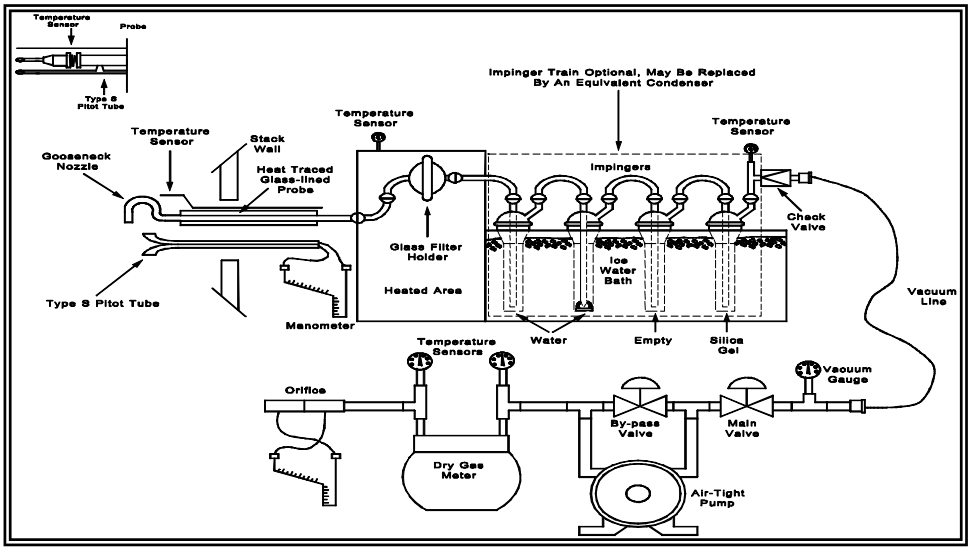
METHOD 4 – "Determination of Moisture Content in Stack Gases"

Method 4 was included in the Method 5 tests.

METHOD 5 – "Determination Of Particulate Emissions From Stationary Sources"

Three Method 5 test runs were performed. Aspen used a stainless steel probe liner in lieu of a glass probe liner for these tests. Isokinetics measured on the high end of the EPA limits (test results averaged 109 percent, EPA limits are 90 to 110 percent); however, isokinetics were within EPA specifications for a valid test run. Figure 4-2 is a diagram of the sample train system used in testing the Hurst boiler on April 12 and 13, 2004 for PM.

FIGURE 4-2
METHOD 5 SAMPLE TRAIN DIAGRAM



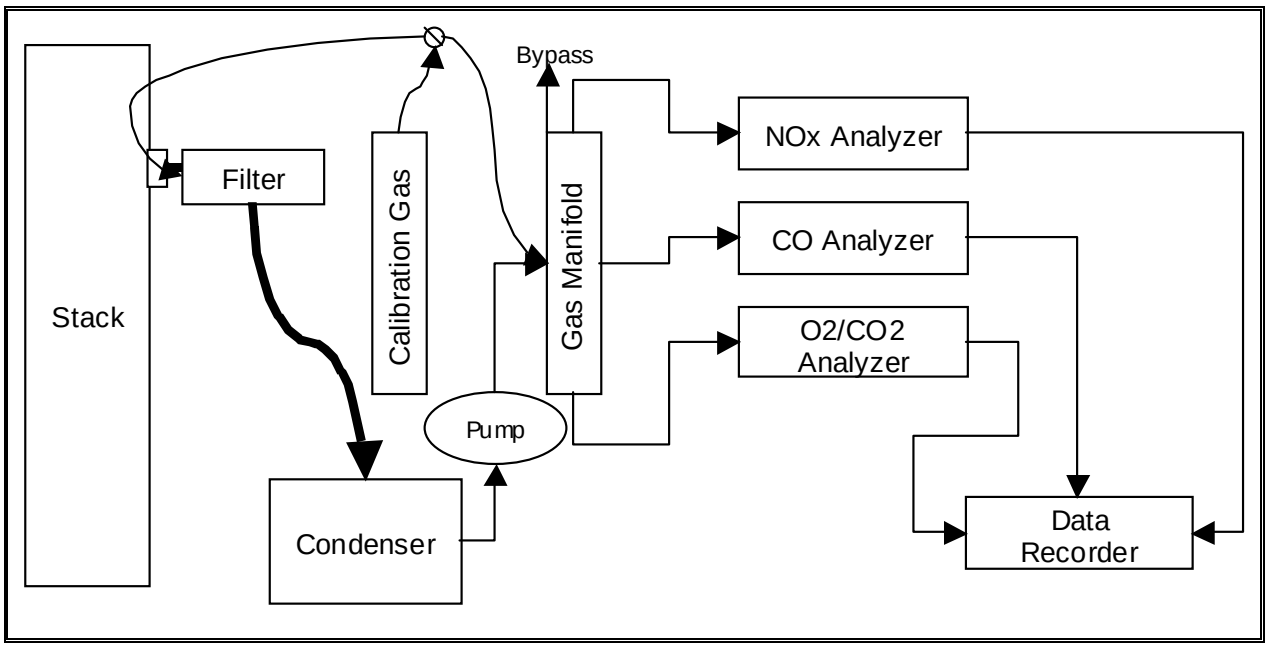
METHOD 7E – Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)

Three 60-minute Method 7E test runs were performed on the Hurst boiler stack. The NO_x analyzer used was a Thermo Environmental (TECO) Model 42C. The analyzer range was set to 1,200 parts per million (ppm). The analyzer system response time was measured to be 41 seconds. Figure 4-3 shows a schematic of the sample train used for the Method 7E tests.

METHOD 10 – Determination of Carbon Monoxide Emissions from Stationary Sources

Three 60-minute Method 10 test runs were performed on the Hurst boiler stack. The CO analyzer used was a TECO Model 48C. The analyzer range was set to 1,200 ppm. Figure 4-3 shows a schematic of the sample train used for the Method 10 tests. The analyzer system response time was measured to be 35 seconds.

FIGURE 4-3
METHODS 7E, 10, AND 3A SAMPLE TRAIN SCHEMATIC



5.0 QUALITY ASSURANCE

All emissions testing equipment was pre-calibrated and post-calibrated in accordance with test and manufacturer method specifications. The probe nozzle used in the emission sampling process was 0.495 inch in diameter. Calibration documentation for the meter box, pitot tubes, nozzles, probes, and calibration gas certifications are included in Appendix C.

Leak checks of the sampling train were performed before and after each test run. Leak checks verify that the gas collected across the filter and through the impingers are from the stack and not from ambient air due to leaks in the sampling system. The amount of acceptable leak, according to Method 5, is 0.02 cubic feet per minute at the highest tested vacuum. Leak check volumes and time intervals for the sampling train are listed in Table 5-1.

TABLE 5-1
SUMMARY OF LEAK CHECK VALUES

Source		Post Check Volumes (CFM)	Post Check Vacuum (in Hg)	Highest Test Vacuum (in Hg)
Boiler	Run 1	0.00	5	4
	Run 2	0.00	5	3.5
	Run 3	0.00	5	4.5

Notes:
CFM Cubic Feet Per Minute
in Hg Inches of Mercury

APPENDIX A

ANALYTICAL DATA

APPENDIX B

SAMPLE CALCULATIONS, SPREADSHEETS AND FIELD DATA

APPENDIX C

CALIBRATION DATA